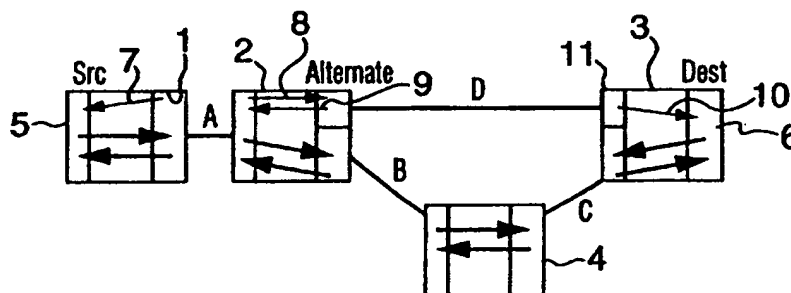




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(54) Title: HIGH AVAILABILITY ATM VIRTUAL CONNECTIONS



(57) Abstract

A method of establishing and maintaining a connection through an asynchronous cell-based network having a plurality of switching nodes, comprises setting up a first bi-directional path between source and destination endpoints through one or more switching nodes, setting up an alternate bi-directional path between the endpoints, and switching from first path to the alternate path by first causing the destination endpoint to send cells back to the source endpoint over the alternate path while still receiving cells over the first path. When the source endpoint receives an indication that the destination endpoint has transferred to the alternate path, it sends cells from the source endpoint to the destination endpoint to complete the transfer to the alternate path.

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HIGH AVAILABILITY ATM VIRTUAL CONNECTIONS

This invention relates to the field of packet-based networks, such as ATM (asynchronous transfer mode), and more particularly to a method for establishing virtual connections that experience minimal downtime in the network.

5 The use of ATM by a continuously widening set of applications is driving a requirement for very robust, highly available connections. Mission critical applications require that ATM virtual connections(VCs) experience very low or no down time when reacting to network failures or network maintenance operations. These ATM virtual connections come in three forms: PVCs (Permanent Virtual Connections), and dynamic
10 on-demand SVCs (Switched Virtual Connections) and SPVCs (Soft Permanent Virtual Connections). SVCs are set up on demand via a signalling protocol and are not automatically re-established after a system restart. SPVCs are signalled PVCs which are set up on demand via a signalling protocol. These PVCs are automatically re-established after a system restart. SVCs and SPVCs enable a network to setup connections on-
15 demand via signaling and routing without the aid of a centrally managed network management platform and are, thus, more robust and efficient than PVCs as the call processing is distributed. SVCs and SPVCs reroute around network failures as soon as the failures are detected. When reacting to network failures, SVCs and SPVCs are torn down, and resignalled and rerouted around the failure. Even though today's current ATM
20 connection management strategy using SVCs and SPVCs enjoy an order of magnitude better rerouting performance than a network management platform can provide with PVCs, rerouting performance is still not adequate for mission critical applications where high availability virtual connections are required.

25 An object of the invention is to provide an arrangement that that enables VCs to experience low or no down time for VCs recovering from network failures or from network maintenance and optimization operations.

30 According to the present invention there is provided a method of establishing and maintaining a connection through an asynchronous cell-based network having a plurality of switching nodes, comprising setting up a first bi-directional path between source and destination endpoints through one or more switching nodes, setting up an alternate bi-directional path between said endpoints, and switching from first path to the alternate path

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by first causing the destination endpoint to send cells back to the source endpoint over the alternate path while still receiving cells over the first path, and when the source endpoint receives an indication that the destination endpoint has transferred to the alternate path, sending cells from the source endpoint to the destination endpoint to complete the transfer to the alternate path.

This arrangement for the handling of network failures and maintenance operations ensures that a backup or alternate data path exists for each mission critical virtual connection. However, when the alternate data path is setup, the determination of how and when to switch to the alternate path is different depending on whether a network fault is being processed or a maintenance operation is processed. If a maintenance operation is being processed then a first mechanism, known as a Bridge and Roll, is used. If a network reroute is being processed, then a second mechanism, known as a RAPID mechanism, is used.

The establishment of an alternate backup VC combined with an efficient determination and mechanism to switch to the alternate path ensures very high availability of mission critical VCs, much more so than waiting for each VC to be resignalled and routed.

The invention also provides an asynchronous cell-based network comprising a plurality of switching nodes interconnected by trunks, means for setting up a first bi-directional path between source and destination endpoints through one or more said switching nodes, means for setting up an alternate bi-directional path between said endpoints, and means for switching from first path to the alternate path by first causing the destination endpoint to send cells back to the source endpoint over the alternate path while still receiving cells over the first path, and when the source endpoint receives an indication that the destination endpoint has transferred to the alternate path, sending cells from the source endpoint to the destination endpoint to complete the transfer to the alternate path.

The invention will now be described in more detail, by way of example, only with reference to the accompanying drawings, in which:-

Figure 1 shows the setting up of the bridge in a bridge and roll mechanism in an ATM network;

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Figure 2 shows the system rolling to the alternate;

Figure 3 shows the bridge and roll mechanism in the final state; and

Figure 4 shows the physical arrangement of an ATM switch in more detail.

Referring to Figure 1, an ATM network includes switch nodes 1, 2, 3, 4, for
5 example, Newbridge Networks Corporation 37170 switches, interconnected by trunks A, B, C, D.

Figure 4 shows the physical arrangement of in more detail. As shown in Figure 4,
the ATM switch A is connected to ATM switch B over an ATM trunk 20 with virtual
path cloud 21 carrying the virtual connections. A DS1 TDM trunk 22 or DS3 TDM trunk
10 23 is connected to circuit emulation card 3. A signaled permanent virtual circuit 25
extends through the switching fabric 26 to the ATM trunk 20.

The switch A also includes a control card 27 supporting CPSS (Control Packet
Switching System), a service card 28, and a P-NNI (Private Network Node Interface) card
29.

15 The switch B is similar to the switch A except that a 46020 network manager is
connected to the control card via a CPSS link.

The S-PVC 25 carried over the ATM trunk extends through the switching fabric
of switch 26 to OC3 circuit 30 which produces an OC3 TDM signal for transfer to the
customer user terminal 31 over an ILMI (Interim Local Management Interface) 32.

20 The P-NNI Interface is a protocol for use between private ATM switches. P-NNI
includes a protocol for distributing topology information between switches and clusters of
switches, used to compute paths through the network, and a signalling protocol used to
establish point-to-point or point-to-multipoint connections across the ATM network. The
signalling protocol is based on ATM Forum UNI signalling, with extensions to support P-
25 NNI functions.

Bridge and roll is a feature which allows the setup of an alternate SPVC path using
the same endpoints as an original SPVC in order to (re)optimize the path or to setup
around equipment which needs maintenance. The goal of the operation is to reduce or
even eliminate service interruption. If the alternate path can be setup, and a quick switch

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over from primary to alternate can take place, then a minimal or even no service interruption occurs.

There are two reasons for bridge and roll - optimise and maintenance. Reroutes in a network tend to leave the network in a sub-optimal state after a sequence of equipment failure and recovery. SPVCs are routed around equipment failure and left in that state when the equipment recovers and thus become sub-optimally routed. At some point, it is desirable to get the SPVC back on the most optimal route as unnecessary bandwidth is being consumed by an SPVC taking more hops than necessary. To minimise the service hit to the path, a bridge and roll operation can be done on the path.

The other reason for bridge and roll is to take equipment out-of-service for maintenance. Consider a series of paths that are routed over a Trunk Group on an OC3 card. If the OC3 card requires an upgrade, then a bridge and roll maintenance operation can be performed on all SPVCs on the trunk group to minimise service interruption.

In Figure 1, an original path is setup along the trunks A, B, C with bi-directional connections at the source 5 and destination 6 endpoints. This path takes three hops versus an optimal two hops. The path uses the route indicated by the bold arrows.

An alternate path is setup over an alternate route by routing a new path along the top two trunks A, D. A uni-directional cross-connect 7 is made at the source endpoint for the alternate path. The source and destination endpoints still transmit over the original route. The alternate connects 8, 9 are indicated by a regular arrow.

The middle switch 2 now has two independent bi-directional cross-connects 8, 9. The source switch has provisioned resources for two concurrent paths over the same physical trunk A. This is temporarily done until the roll operation occurs.

The destination switch sets up the last leg of its route but it too makes a uni-directional cross-connect 10 from the line card 11 toward the destination endpoint.

This sequence completes the bridge.

As shown in Figure 2, when a bridge request reaches the destination, a roll is required because the new route is cheaper than the original route assuming equal administrative weight on all trunks. The destination switch 3 rolls its cross-connect 10 to the alternate path. It does this by changing the line card to which it transmits. At this

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point, the source is transmitting over the original route but it is receiving cells over the alternate route. The destination now indicates back to the source that it has rolled to its alternate.

5 When the source receives the indication that the destination had rolled, the source rolls to its alternate. At this point, only the alternate path is used and no data is being sent over the original path.

This sequence completes the roll. Figure 3 shows the final state of the bridge and roll operation.

10 The original path is then released thus freeing up the bandwidth used by the original route.

For whatever reason, in both the optimise and maintenance operations, if the alternate SPVC path cannot be successfully routed, then the original path is left alone.

15 The example above illustrates the optimise operation. If an alternate path cannot be successfully routed, then the existing path remains active. The current administrative weight of the SPVC path being optimised is used when routing the alternate. Anywhere along the path, the alternate can be rejected because it weighed more than the original SPVC path.

20 There exist scenarios in which there appears to be an optimal route for the SPVC path but the alternate SPVC path cannot be routed optimally. Because the alternate SPVC is routed as a completely independent path, thus using new cross-connects and bandwidth, an optimal route may be discarded due to CAC (Connection Admission Control) failures. If this is the case, then the alternate may end up on an even more costly route than the original and hence the original path is unaffected.

25 The maintenance operation behaves similarly to the optimize functionality except the destination always rolls to the alternate if the path can be successfully routed. The following procedure illustrates the use of bridge and roll maintenance.

30 The equipment undergoing maintenance is placed in a courtesy down state such that no new SPVCs are routed over the equipment and additionally, existing paths are not affected. Then, each SPVC running over the equipment to-be-maintained is bridged and rolled. Because the new alternate SPVCs will not take the route that the original took as

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routing ensures that administratively disabled equipment is avoided, the path is routed around the disabled equipment.

The service interruption for a bridge and roll operation is quantified as follows.

When an SPVC path is bridged and rolled, the possibility exists for cell loss or cell reordering in two locations. The first occurs when the switch is made at the destination, and second when the switch is made at the source. The service impact to CPE equipment is, of course, application dependent. Example: a CES application may experience a framing error if cells are lost or misordered and thus realize potentially a severely errored second in each direction.

10 The cell loss may occur when the source or destination reconnects its transmit to the alternate path. The cell loss may occur if cells were being transmitted at the time of the switch. Cell re-ordering may occur when the end to end cell delay of the alternate path is less than that of the original path. Again, this is dependent on the frequency of cell flow when the switch to the alternate occurs.

15 Note that a switch at either end may occur such that no cells are lost or misordered and thus no interruption is perceived by the maintenance operation.

Reserved Alternate Path with Interruption Detection (RAPID) is similar to bridge and roll. However, for a mission critical virtual connection, both a primary and an alternate path are setup at VC creation time. Also, the endpoints transmit data only on the primary path. To handle a network fault, as soon as the endpoints detect a fault, a switch to the alternate occurs using the same mechanism as in bridge&roll, i.e., the transmit at each endpoint is switched to the alternate. There are many ways in which to detect a failure. If a network fails, the endpoints may experience VC AIS and can make the switch from primary to alternate. If however, the primary path is released via signaling, then a switch to the alternate can be made, and the primary can be resignalled however, it will act as the new alternate.

25 RAPID is useful for both SVCs and SPVCs. Very fast reroute times are obtained by RAPID VCs because as soon as fault detection occurs, a switch from primary path to alternate occurs at each end of the path. Contrast this with the latency for an entire new path to be resignaled.

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Claims:

1. A method of establishing and maintaining a connection through an asynchronous cell-based network having a plurality of switching nodes, comprising setting up a first bi-directional path between source and destination endpoints through one or more switching
5 nodes, setting up an alternate bi-directional path between said endpoints, and switching from first path to the alternate path by first causing the destination endpoint to send cells back to the source endpoint over the alternate path while still receiving cells over the first path, and when the source endpoint receives an indication that the destination endpoint has transferred to the alternate path, sending cells from the source endpoint to the
10 destination endpoint to complete the transfer to the alternate path.
2. A method as claimed in claim 1, wherein said transfer is effected to optimize the route between the source and destination endpoints.
3. A method as claimed in claim 1, wherein said transfer is effected to permit maintenance of equipment within the network.
- 15 4. A method as claimed in claim 1, wherein said switching nodes are ATM switches.
5. A method as claimed in claim 1, wherein said paths are switched virtual permanent connections.
6. A method as claimed in claim 1, wherein during the set-up of the alternate path the source switch provisions resources for two concurrent paths over the same trunk.
- 20 7. A method as claimed in claim 1, wherein said switching to said alternate path occurs to optimize routing.
8. A method as claimed in claim 1, wherein said switching to said alternate path occurs to permit maintenance.
9. A method as claimed in claim 8, wherein said alternate path is set up substantially
25 at the same time as said first path.
10. An asynchronous cell-based network comprising a plurality of switching nodes interconnected by trunks, means for setting up a first bi-directional path between source and destination endpoints through one or more said switching nodes, means for setting up an alternate bi-directional path between said endpoints, and means for switching from first

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path to the alternate path by first causing the destination endpoint to send cells back to the source endpoint over the alternate path while still receiving cells over the first path, and when the source endpoint receives an indication that the destination endpoint has transferred to the alternate path, sending cells from the source endpoint to the destination endpoint to complete the transfer to the alternate path.

5

11. An asynchronous cell-based network as claimed in claim 10, wherein said switching nodes are ATM switches.

12. An asynchronous cell-based network as claimed in claim 11, wherein said paths are switched virtual permanent connections.

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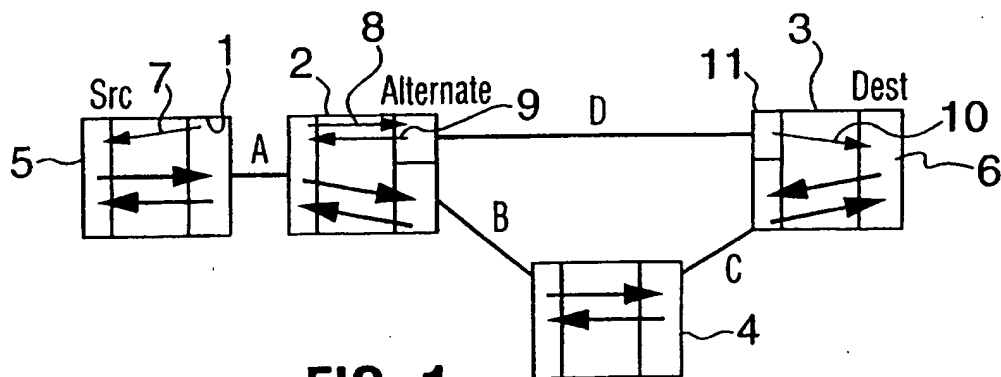


FIG. 1

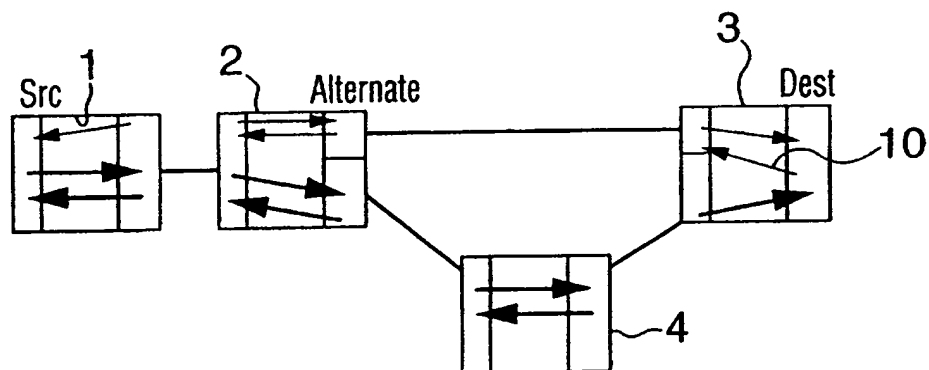


FIG. 2

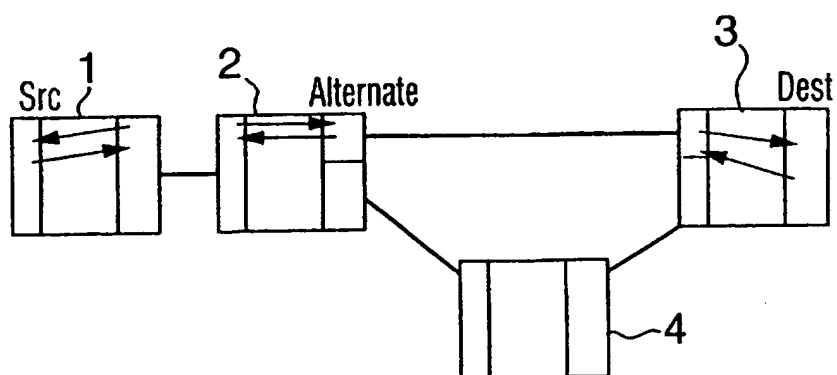


FIG. 3

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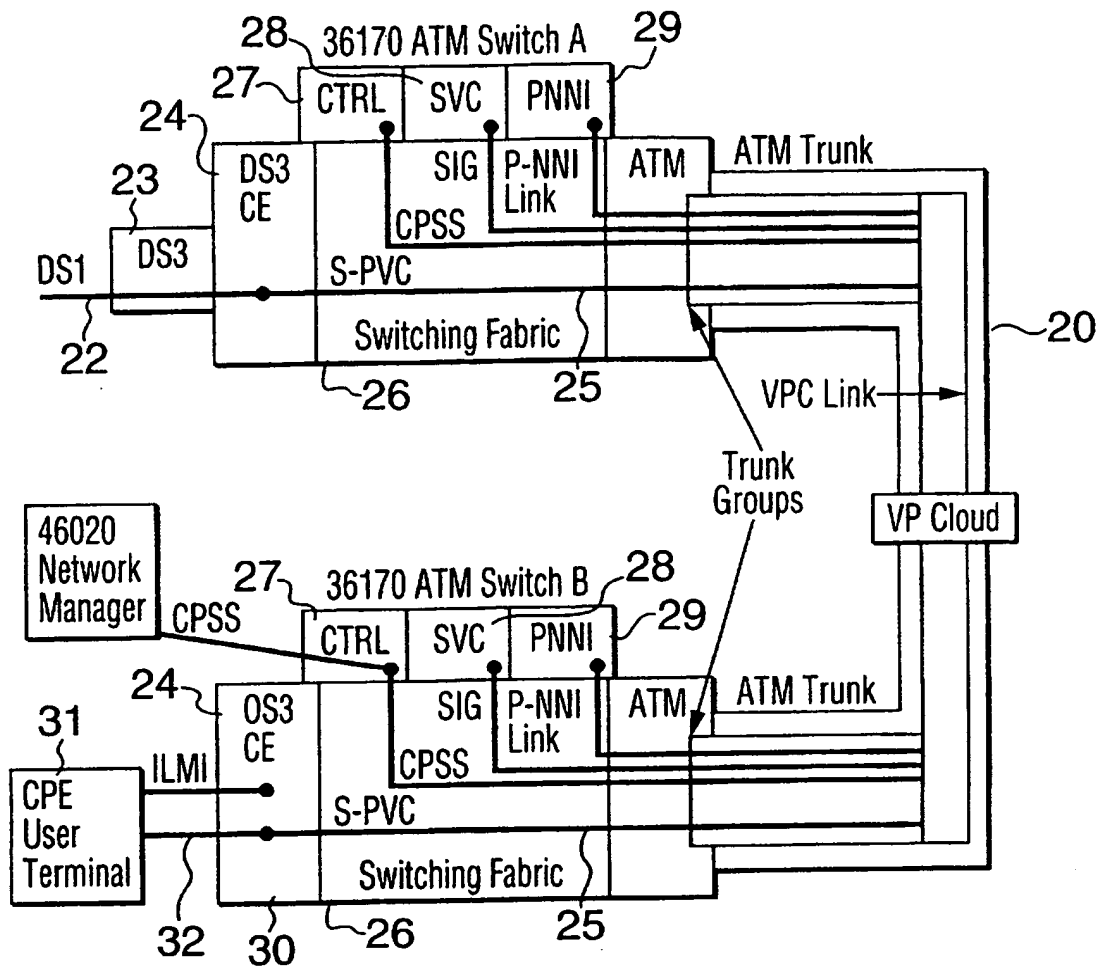


FIG. 4

INTERNATIONAL SEARCH REPORT

Internat: Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RYUTARO KAWAMURA ET AL: "SELF-HEALING ATM NETWORKS BASED ON VIRTUAL PATH CONCEPT" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, vol. 12, no. 1, 1 January 1994, pages 120-127, XP000493893 Paragraph III.B; fig. 4 ---	1,4,10, 11
X	CIVANLAR S ET AL: "SELF-HEALING IN WIDEBAND PACKET NETWORKS" IEEE NETWORK: THE MAGAZINE OF COMPUTER COMMUNICATIONS, vol. 4, no. 1, 1 January 1990, pages 35-39, XP000113853 paragraph "Failure recovery strategy"; Fig.4; --- -/-	1,10

☒ Further documents are listed in the continuation of box C.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>YAMAGUCHI K ET AL: "TRANSPORT SYSTEMS BASED ON FLEXIBLE, NON-STOP ARCHITECTURE" PROCEEDINGS OF THE GLOBAL TELECOMMUNICATIONS CONFERENCE (GLOBECOM), HOUSTON, NOV. 29 - DEC. 2, 1993, vol. 3 OF 4, 29 November 1993, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 1468-1475, XP000436060 see paragraph 2.2.2</p>	1-12
A	<p style="text-align: center;">---</p> <p>WO 95 24085 A (NOKIA TELECOMMUNICATIONS OY ;HAVANSI KLAUS (FI)) 8 September 1995 see abstract</p>	1,10
A	<p style="text-align: center;">---</p> <p>DE 43 31 577 A (SIEMENS AG) 23 March 1995 see abstract</p> <p style="text-align: center;">-----</p>	1,10

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat Application No

PCT/CA 97/00507

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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